AD-A109 904 NAVAL MINE ENGINEERING FACILITY YORKTOWN VA F/G 9/1
CABLE ASSEMBLIES OF THE 900 AND 1800 SERIES: USE OF CAB-O-SIL/A--ETC(U)
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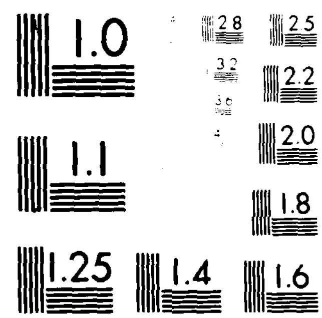

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NAVAL MINE ENGINEERING FACILITY Report

LEVEL

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NAVMINENGRFAC TE-18-76

Subj: Cable Assemblies of the 900 and 1800 Series; use of Cab-O-Sil/ Armstrong Epoxy Resin A-2 mixture in

Ref: (a) "Cab-O-Sil Properties and Functions," Boston: Cabot Corporation, 1975.
(b) Snedecor, George W., Statistical Methods. Ames, Iowa: The Iowa State College Press, 1956.

1. Introduction

During a meeting held at Projects Unlimited on 4 August 1976, the contractor requested assistance from the Naval Mine Engineering Facility in solving a problem with epoxy potting of Cable Assemblies of the 900 and 1800 series presently being made on Contract N00197-75-C-0177. The contractor stated that the two Armstrong epoxy resins specified by DWG 2225882 for potting the backs of connectors are not suitable because of their viscosity. According to the contractor, Armstrong Epoxy Resin A-2 is too thin to use, and Armstrong Resin X-239 is too thick. To rectify the problem of viscosity, the contractor proposed to thicken Armstrong Epoxy Resin A-2 with Cab-O-Sil, a fumed silica. The contractor asked permission to use 0.5% Cab-O-Sil in the Armstrong Epoxy Resin A-2. The Test Engineering Department of the Naval Mine Engineering Facility conducted an investigation to determine if a potting mixture of 0.5% Cab-O-Sil in the Armstrong Epoxy Resin A-2 could be used without any adverse effects on the performance of cable assemblies.

2. Background Information on Cab-O-Sil

Cab-O-Sil, as described in reference (a), is fumed silicon dioxide manufactured by the Cabot Corporation of Boston, Massachusetts. The silica has an extremely small particle size, a high purity, and a chain-forming tendency. Because of its excellent dielectric properties, the material is frequently used in reinforcement applications for electrical insulation. Cab-O-Sil is a hydroscopic material. Gas absorption studies have proven that the silica is non-porous. Therefore, water adsorption and evaporation are accelerated, since the molecules of liquid are only held physically on exterior surfaces, not entrapped in pores.

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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Use of CAB-O-SIL a fumed silica as a thickener for an Epoxy Resin in a potting process.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Evaluation tests were conducted to determine the effects on the electrical properties of the cured epoxy when as much as .5% CAB-O-SIL was added to the epoxy during mixing.

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3. Procedure

(a) To determine the effect of Cab-O-Sil on the physical and electrical properties of Armstrong Epoxy Resin A-2, certain physical and electrical tests were conducted on molded plugs of Armstrong Epoxy Resin A-2. Samples of Armstrong Epoxy Resin A-2, Armstrong Epoxy Resin A-2 with 0.25% Cab-O-Sil, and Armstrong Epoxy Resin A-2 with 0.50% Cab-O-Sil were molded, cured, and then tested for volume resistivity, water absorption, and volume resistivity after 24 hours of submersion in water.

(b) To determine the effect of Cab-O-Sil on the electrical properties of fabricated cables, a Cable Assembly CA-831, having the connectors potted with the 0.5% Cab-O-Sil/Armstrong Epoxy Resin A-2 mixture, was obtained from Projects Unlimited. A Cable Assembly CA-1832, manufactured by Projects Unlimited without Cab-O-Sil added to the epoxy, was also obtained. The following tests were performed on both cables:

(1) Continuity of cables as received according to DWG 1386089, using a Leeds & Northrup Wheatstone Bridge, S/N 1790432

(2) Insulation resistance of cables after conditioning at 75 ± 5°F and 75 ± 5% relative humidity for 24 hours according to DWG 1386089, using a General Radio Model 1862-C Megohmmeter, S/N 856

(3) Continuity and insulation resistance after a fourteen day temperature and humidity cycle according to DWG 1386089, except for the exclusion of the packaging

(4) Continuity and insulation resistance after shock and vibration treatment according to DWG 1386089

(c) For each electrical test described in paragraph 3b, 50 measurements for each cable assembly were chosen randomly. Each set of data was analyzed statistically using the t-test for significant differences between means as explained in Chapter 2 of reference (b).

4. Results

(a) Data from the tests performed on the molded plugs are listed below in Table 1.

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TABLE 1

Electrical and Physical Properties of Epoxy Plugs

Property	Epoxy Plugs without Cab-O-Sil	Epoxy Plugs with 0.25% Cab-O-Sil	Epoxy Plugs with 0.50% Cab-O-Sil
Volume Resistivity (25°C)	$6.7 \times 10^8 \Omega$-in	$6.7 \times 10^8 \Omega$-in	$6.7 \times 10^8 \Omega$-in
Water Absorption (24 hr. submersion; 25° C)	0.081%	0.148%	0.123%
Volume Resistivity after submersion in-water for 24 hrs (25°C)	$6.7 \times 10^8 \Omega$-in	$6.7 \times 10^8 \Omega$-in	$6.7 \times 10^8 \Omega$-in

These tests showed that the plugs with Cab-O-Sil absorbed over one and a half times more water than the plug without Cab-O-Sil. The volume resistivities of all three plugs, however, were identical, even after submersion in-water for 24 hours.

(b) Tables 2 - 7 contain data from tests described in paragraph 3b. Statistical data from the t-test for each set of data are given in Table 8. By observing the data given in the tables, the following statements can be made:

(1) In the as received condition and after environmental exposure, the continuity of both cables remained well under the specified resistance of ≤ 0.5 , as shown by Tables 2, 4 and 6. Under all conditions the t-tests showed that the continuity of the cable with Cab-O-Sil was not statistically different from the continuity of the cable assembly without Cab-O-Sil.

(2) The cables passed the insulation resistance requirement of ≥ 50 megohms after conditioning, but not all measurements passed the requirement after the temperature and humidity cycle and the shock and vibration treatment as shown in Tables 3, 5 and 7. These failures

probably resulted due to the direct exposure of the unpackaged cables to moisture. Again, however, the t-tests showed that there were no significant differences in insulation resistances under any of the conditions for the two cable assemblies.

(3) Under all conditions, the mean value of each set of data passed the continuity or insulation resistance requirements of DWG 1386089 as shown by Table 8.

(4) Under all conditions, the cable assembly potted with the Cab-O-Sil/Armstrong Epoxy Resin A-2 mixture exhibited a mean insulation resistance that was higher than the insulation resistance of the cable assembly not potted with the Cab-O-Sil/Armstrong Epoxy Resin A-2 mixture as shown by Table 8.

5. Conclusions

From the data obtained during the investigation, the following conclusions can be made:

(a) The addition of Cab-O-Sil to the Armstrong Epoxy Resin A-2 results in greater moisture absorption, but the electrical resistivity of the Cab-O-Sil/Armstrong Epoxy Resin A-2 mixture is essentially the same as that of pure Armstrong Epoxy Resin A-2.

(b) Electrical continuity and insulation resistance properties for cable assemblies containing Cab-O-Sil/Armstrong Epoxy Resin A-2 are not statistically different from the same properties for cable assemblies potted with pure Armstrong Epoxy Resin A-2 in the as received condition, after temperature/humidity cycling, and after shock and vibration treatment.

6. Recommendations

Based on the above conclusions, it is recommended that Projects Unlimited be allowed to use a mixture of 0.5% Cab-O-Sil in Armstrong Epoxy Resin A-2 for potting connectors used in Cable Assemblies of the 900 and 1800 series.

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TABLE 2

Random Continuity Resistance Measurements of Cables

As Received (Ω)

CA-831

0.031	0.039	0.025	0.057	0.191
0.025	0.074	0.028	0.057	0.059
0.058	0.041	0.030	0.057	0.191
0.031	0.053	0.070	0.057	0.189
0.040	0.054	0.029	0.057	0.158
0.025	0.054	0.027	0.050	0.086
0.058	0.053	0.030	0.059	0.059
0.040	0.070	0.027	0.057	0.060
0.058	0.042	0.070	0.056	0.191
0.047	0.028	0.025	0.056	0.191

CA-1832

0.049	0.044	0.104	0.049	0.050
0.038	0.053	0.070	0.069	0.036
0.043	0.046	0.080	0.049	0.043
0.048	0.031	0.047	0.036	0.050
0.052	0.033	0.047	0.038	0.031
0.049	0.033	0.037	0.029	0.077
0.052	0.046	0.031	0.029	0.036
0.049	0.031	0.081	0.049	0.043
0.055	0.055	0.081	0.038	0.047

Specified continuity resistance per DWG 1386089: $\leq 0.5\,\Omega$

TABLE 3

Random Insulation Resistance Measurements of Cables

After Conditioning ($\Omega \times 10^{10}$)

CA-831

15.0	50.0	50.0	0.35	0.25
5.0	40.0	40.0	40.00	20.00
15.0	60.0	20.0	1.40	1.00
1.5	50.0	30.0	20.00	5.00
20.0	20.0	50.0	50.00	3.00
15.0	10.0	100.0	50.00	10.00
100.0	5.0	1.5	3.00	20.00
4.0	80.0	40.0	100.00	15.00
15.0	0.6	1.5	16.00	20.00
8.0	0.2	50.0	13.00	0.30

CA-1832

1.18	6.80	7.10	1.40	0.51
2.00	66.00	0.99	9.40	3.80
1.80	14.00	5.60	3.90	0.70
1.90	4.80	9.10	1.40	1.00
1.60	0.62	7.50	1.10	6.40
0.64	0.55	1.70	0.42	0.66
1.60	7.10	1.40	1.60	4.30
0.94	2.00	1.20	0.85	6.20
5.20	1.80	3.30	1.20	110.00
0.21	0.97	1.50	9.20	220.00

Specified insulation resistance per DWG 1386089: $\geq 5.0 \times 10^7 \Omega$

TABLE 4

Random Continuity Resistance Measurements of Cables

After Jan Cycle (Ω)

CA-831

0.043	0.067	0.046	0.046	0.049
0.062	0.025	0.051	0.029	0.045
0.059	0.029	0.051	0.033	0.041
0.091	0.147	0.054	0.049	0.035
0.032	0.051	0.049	0.075	0.035
0.090	0.067	0.051	0.047	0.075
0.032	0.067	0.051	0.075	0.035
0.091	0.051	0.051	0.029	0.049
0.043	0.026	0.049	0.029	0.035
0.090	0.026	0.051	0.049	0.049

CA-1832

0.040	0.036	0.057	0.040	0.032
0.046	0.036	0.049	0.040	0.041
0.070	0.098	0.057	0.040	0.039
0.078	0.088	0.074	0.079	0.050
0.078	0.085	0.057	0.051	0.050
0.039	0.085	0.057	0.053	0.032
0.032	0.076	0.057	0.062	0.041
0.078	0.076	0.063	0.062	0.056
0.041	0.098	0.061	0.052	0.032
0.070	0.032	0.057	0.052	0.041

Specified continuity per DWG 136089: $\leq 0.5\ \Omega$

TABLE 5

Random Insulation Resistance Measurement of Cables

After Jan Cycle ($\Omega \times 10^7$)

CA-831

52.0	0.92	1.30	0.72	1.50
52.0	1.90	1.20	4.50	0.45
52.0	0.92	3.70	37.00	1.00
6.2	0.92	1.20	45.00	0.82
4.8	370.00	5.20	0.56	1.50
3.0	1.30	3.70	1.60	0.28
3.8	0.92	98.00	26.00	0.82
2.8	0.92	1.20	2.20	21.00
52.0	1.90	0.12	0.56	0.82
9.2	1.90	1.20	4.50	1.90

CA-1832

0.068	0.280	0.22	0.160	0.140
0.070	0.070	1.30	0.110	0.200
0.070	0.088	0.08	0.140	90.000
0.110	0.160	0.18	0.140	0.240
0.056	1.600	0.12	0.190	0.200
0.120	0.160	1.30	0.340	0.200
0.070	0.088	0.22	0.190	0.062
0.057	1.600	0.27	0.180	0.140
60.000	1.600	1.60	0.056	0.062
0.070	0.160	0.15	0.180	86.000

Specified insulation resistance per DWG 1386089: $\geq 5.0 \times 10^7 \Omega$

TABLE 6

Random Continuity Resistance Measurements of Cables

After Shock and Vibration Treatment (Ω)

CA-831

0.032	0.156	0.056	0.032	0.081
0.059	0.156	0.057	0.052	0.060
0.033	0.130	0.057	0.058	0.049
0.057	0.034	0.057	0.080	0,049
0.057	0.068	0.081	0.058	0.036
0.033	0.068	0.055	0.052	0.060
0.095	0.072	0.081	0.074	0.081
0.033	0.077	0.057	0.074	0.060
0.097	0.130	0.056	0.052	0.039
0.033	0.032	0.081	0.058	0.060

CA-1832

0.039	0.035	0.060	0.081	0.058
0.042	0.033	0.058	0.062	0.033
0.071	0.087	0.058	0.052	0.041
0.042	0.064	0.074	0.064	0.033
0.042	0.085	0.074	0.053	0.084
0.041	0.074	0.056	0.053	0.032
0.071	0.074	0.058	0.053	0.038
0.033	0.064	0.074	0.081	0.051
0.071	0.099	0.056	0.064	0.050
0.071	0.099	0.051	0.053	0.033

Specified continuity resistance per DWG 1386089: $\leq 0.5\,\Omega$

TABLE 7

Random Insulation Resistance Measurements of Cables

After Shock and Vibration Treatment

($\Omega \times 10^7$)

CA-831

0.76	9.3	9.20	1.0	160.00
1.20	80.0	9.20	4.3	0.56
17.00	120.0	4.50	16.0	0.10
1.20	120.0	0.24	30.0	11.00
0.88	5.9	9.20	300.0	0.56
2.30	4.8	3.90	27.0	1.10
0.36	180.0	3.90	27.0	0.44
2.30	4.9	2.00	4.3	4.10
0.64	4.9	2.20	1.0	0.56
17.00	12.0	4.50	1.0	2.40

CA-1832

0.80	0.440	0.53	0.700	0.18
0.48	5.800	0.53	0.078	0.13
0.15	0.400	0.36	3.300	7.00
0.24	5.800	0.40	0.130	0.59
0.18	0.400	2.10	0.640	92.00
0.08	0.076	0.39	0.078	0.18
0.15	3.500	0.11	0.270	0.42
0.24	0.400	0.11	0.140	0.59
0.08	3.500	0.63	0.078	6.40
0.18	5.800	0.40	3.300	0.42

Specified insulation resistance per DWG 1386089: $\geq 5.0 \times 10^7 \Omega$

TABLE 8

Calculated Measurements Used In t-test Analysis

Continuity*	Mean ($\Omega \times 10^{-2}$)	Standard Deviation ($\Omega \times 10^{-2}$)	$\sigma_{m_{est}}$ ($\Omega \times 10^{-3}$)	σ_{diff} ($\Omega \times 10^{-3}$)	t***
As received:					
CA-831	6.440	4.760	6.732	7.140	2.117
CA-1832	4.928	1.677	2.372		
After Jan Cycle:					
CA-831	5.204	2.231	3.155	4.078	1.050
CA-1832	5.632	1.827	2.584		
After Shock & Vibration:					
CA-831	6.316	3.022	4.273	5.260	1.441
CA-1832	5.558	2.169	3.068		

Insulation Resistance**	Mean ($\Omega \times 10^{8}$)	Standard Deviation ($\Omega \times 10^{8}$)	$\sigma_{m_{est}}$ ($\Omega \times 10^{7}$)	σ_{diff} ($\Omega \times 10^{7}$)	t***
After Conditioning:					
CA-831	2571.2	2728.5	3858.6	6269.9	2.362
CA-1832	1090.3	3494.5	4942.0		
After Jan Cycle:					
CA-831	1.7779	5.4650	7.729	8.1865	1.559
CA-1832	0.5017	1.9087	2.699		
After Shock & Vibration:					
CA-831	2.4554	5.6626	8.008	8.2159	2.623
CA-1832	0.3003	1.2983	1.836		

* Specified continuity resistance per DWG 1386089: $\leq 0.5\Omega$

** Specified insulation resistance per DWG 1386089: $\geq 5 \times 10^{7}\Omega$

*** For significant difference at the 99% confidence level, t has to be > 2.678